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| 8. | ABSTRACT<br>Abstract should not contain any [E.g. !@#$%^&*() etc. and more than 2048 characters will not be acceptable] | The increasing popularity of 3 versus 3 (3v3) basketball have created a growing need for efficient recovery strategies due to the sport's intense pace, short match durations, and frequent back-to-back games. The present study will investigate the effects of five recovery strategies—active recovery, massage, foam rolling, active recovery combined with massage, and active recovery combined with foam rolling—on selected physiological variables (blood lactate, heart rate, body temperature, systolic and diastolic blood pressure) and physical ability variables (sprinting ability, explosive strength, agility) following a 3v3 basketball match.<br><br>Twenty-one male players aged 18–25 years, who have participated in INBL or RED BULL Half Court tournaments, will be selected for the study. A within-subject, repeated measures experimental design will be employed. Physiological and physical ability data will be collected at pre-match, immediately post-match, and post-recovery |

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| | | **intervals (10 and 15 minutes). Tests will include blood lactate measurement, heart rate monitoring, digital thermometry, blood pressure assessment, 15m sprint test, standing broad jump, and T-test for agility.**<br><br>**Data will be analyzed using two-way repeated measures ANOVA at a significance level of 0.05. Based on previous findings, it is expected that active recovery will facilitate faster lactate clearance, while massage and foam rolling may offer psychological and localized muscular benefits. The study will aim to identify the most effective recovery method for optimizing performance and minimizing fatigue in 3v3 basketball players, thereby providing valuable guidance for athletes and coaches.** |
| **9.** | **KEYWORDS**<br>**(please mention more than one keyword)** | **Active Recovery, Massage, Foam Rolling, Combination Modality, Sprint Ability, Agility, Explosive Strength.** |
| **10.** | **LANGUAGE** | **ENGLISH** |
| **11.** | **ATTACH SYNOPSIS**<br>**(PDF not more than 10 MB)** | **SYNOPSIS ATTACHED** |

# COMPARATIVE EFFECT OF DIFFERENT RECOVERY STRATEGIES ON SELECTED PHYSIOLOGICAL AND PHYSICAL ABILITY AFTER 3 VERSUS 3 BASKETBALL MATCH


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## SHORT SYNOPSIS

Submitted in partial fulfilment of the requirements of the degree of

**DOCTOR OF PHILOSOPHY**

**to**

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## Lakshmibai National Institute of Physical Education, NERC, Guwahati

## Certificate

I hereby declare that the short synopsis titled "**Comparative Effect of Different Recovery Strategies on Selected Physiological and Physical Ability After 3 versus 3 Basketball Match"** being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Physical Education from Lakshmibai National Institute of Physical Education, NERC, Guwahati during academic year 2021-22.

It is a bonafide record of original work carried out under the supervision of Dr. Ramesh Chand Yadav and has not been submitted in full or in part to any other university or institute for a degree or diploma. Further, it is certified that the short synopsis is plagiarism-free, and proof has been submitted.

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## ABSTRACT

The increasing popularity of 3 versus 3 (3v3) basketball have created a growing need for efficient recovery strategies due to the sport's intense pace, short match durations, and frequent back-to-back games. The present study will investigate the effects of five recovery strategies—active recovery, massage, foam rolling, active recovery combined with massage, and active recovery combined with foam rolling—on selected physiological variables (blood lactate, heart rate, body temperature, systolic and diastolic blood pressure) and physical ability variables (sprinting ability, explosive strength, agility) following a 3v3 basketball match.

Twenty-one male players aged 18–25 years, who have participated in INBL or RED BULL Half Court tournaments, will be selected for the study. A within-subject, repeated measures experimental design will be employed. Physiological and physical ability data will be collected at pre-match, immediately post-match, and post-recovery intervals (10 and 15 minutes). Tests will include blood lactate measurement, heart rate monitoring, digital thermometry, blood pressure assessment, 15m sprint test, standing broad jump, and T-test for agility.

Data will be analyzed using two-way repeated measures ANOVA at a significance level of 0.05. Based on previous findings, it is expected that active recovery will facilitate faster lactate clearance, while massage and foam rolling may offer psychological and localized muscular benefits. The study will aim to identify the most effective recovery method for optimizing performance and minimizing fatigue in 3v3 basketball players, thereby providing valuable guidance for athletes and coaches.



**Keywords**: Active Recovery, Massage, Foam Rolling, Combination Modality, Sprint Ability, Agility, Explosive Strength.

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# CHAPTER I

# INTRODUCTION

Most popular sports around the world have been evolving over the last few decades. One of the most common evolutions of sports has been the creation of shorter formats to make the game quicker, more competitive, and easier for fans to watch.

Cricket has T20 as the shortest format of the game. Football has the 11v11 full match and the 5v5 shorter version, with the field size and match time reducing as well as the number of players. Rugby also has the 15s and 7s formats, with varying field sizes and match timings. And basketball has the 5v5 and the 3v3 formats.

Unlike other sports, there are vast differences between the 2 formats of the basketball game and these are especially evident to people that play the sport. The easy changes to spot are that 5v5 is a 40-minute game played by two teams of five players each on a full court, while 3v3 is a 10-minute game played by two teams of three players each on half court. But if you look further into the two formats, you can see that the game completely changes and players need a whole new approach to succeed. That's what makes it exciting; players who excel at 5v5 don't necessarily do well in 3v3, unlike other games where there is an overlap of athletes over different formats.

The 5v5 format of standard basketball is slower than the intense 3v3 action. With a shorter game time, players have to move quickly to outscore their opponent. At 12 seconds, the shot clock in 3v3 is also half of that used in 5v5, which means scoring attempts have to be made in half the time.

With speed being the most important aspects of the 3v3 game, athletes with better agility tend to perform better. In the 5v5 game, stamina comes into play, but 3v3 is about agility and great conditioning. Players need to go back-and-forth in a small space to perform better in

3v3. Also, with fewer breaks in play and fewer timeouts, there isn't much chance to catch your breath.

3v3 basketball represents a condensed, high-intensity intermittent athletic protocol comprising successive episodes of maximal or near-maximal exertion interspersed with intervals of submaximal effort or passive inactivity. Competitive gameplay is typified by recurrent anaerobic explosive

maneuvers, including sprint accelerations, vertical and horizontal propulsion (jumps), lateral displacements (shuffles), and abrupt directional transitions. In elite-level contemporary 3v3 basketball tournaments, athletes are frequently mandated to participate in sequential fixtures with minimal inter-match recovery duration. To facilitate physiologically adequate recuperation post-competition, it is essential to characterize the nature and extent of exercise-induced fatigue and, where feasible, elucidate its etiological physiological mechanisms. Although empirical validation regarding the efficacy of many restorative protocols remains limited, various recuperative modalities—such as cryotherapy, hydrotherapy, compression therapy, and active recovery regimens—are regularly implemented in basketball settings. Optimizing post-exertional recovery is of paramount significance, particularly because athletes allocate substantially more temporal resources to recuperation than to structured training regimens. The frequency, timing, and quality of recovery interventions are critical determinants of sustaining peak physiological and neuromuscular performance under competitive stress. Sufficient recuperative strategies may yield extensive physiological advantages during prolonged high-load training phases and intensive competition periods (Shona, 2013). Recovery, or physiological regeneration, encompasses the systemic biological processes by which homeostasis is reestablished, and cellular, metabolic, and neuroendocrine functions are restored and adaptively elevated to withstand future exertional demands.

The magnitude and duration of athletic training stimuli critically influence the temporal requirements for physiological and psychological restoration. The effectiveness of the recovery period is inherently contingent upon the adequacy and specificity of the implemented recuperative modalities. Inadequate or suboptimal recovery protocols can precipitate maladaptive responses, including overreaching or overtraining syndromes, which may culminate in the progressive decline of athletic performance capabilities (Whyte et al., 2006). Ensuring a strategic equilibrium between exertional load and recovery processes is paramount to sustaining optimal functional output. The fundamental objective of recovery methodologies is to facilitate repeated training and competitive participation with attenuated levels of residual fatigue and without compromising subsequent performance (Calder, 1998).

In order to expedite the physiological restitution process, sports scientists, conditioning specialists, and elite athletes frequently initiate preemptive recuperation protocols immediately following intensive training bouts or competitive engagements. These modalities may encompass cryogenic therapy, myofascial release through massage, hydrothermal contrast immersion techniques, static

and dynamic stretching routines, elevated oxygen uptake interventions, and the utilization of graduated compression apparel, among others (Hauswirth et al., 2010). To augment the restoration of neuromuscular function and systemic equilibrium, a wide array of scientifically validated recovery interventions have gained prominence among practitioners in high-performance sports settings. The selection and implementation of such strategies are largely contingent upon the specific biomechanical and metabolic demands of the preceding physical exertion, whether arising from structured training regimens or formalized athletic competition. Consequently, a comprehensive evaluation of the physiological and performance-based outcomes associated with various recovery modalities—particularly in relation to their effect on myogenic fatigue attenuation, systemic homeostasis, and subsequent performance optimization—is of paramount significance. Globally, coaches and athletes are systematically incorporating diverse recovery paradigms such as active recovery protocols, passive restoration strategies, submaximal aerobic activities, contrast hydrotherapy, localized cryostimulation, and compression-based garments, in efforts to expedite inter-session recovery during periods of accumulated fatigue or successive competitive exposures (Vaile et al., 2008). To maximize athletic output and mitigate the detrimental effects of overtraining syndrome, recovery programs must be integrated as an essential and periodized element within the overall training microcycle, thereby facilitating effective biological and physiological restoration (Hooper et al., 1995). Sustained exposure to elevated training loads is unsustainable in the absence of systematically reinforced and strategically enhanced recovery mechanisms (Singh H., 1984). The manifestation of fatigue—whether muscular, central, or peripheral—is inherently dependent on the typology and intensity of the performed activity, encompassing physiological, cognitive, nutritional, and neurochemical dimensions, all of which elicit distinct stress responses that collectively contribute to fatigue onset (Allen et al., 1990). From a pathophysiological perspective, fatigue is characterized as an atypical condition of systemic or localized exhaustion resulting in diminished athletic capacity. This phenomenon often emerges when the endogenous energy production pathways fail to adequately satisfy the elevated metabolic demands imposed by prolonged or high-intensity exercise (Pournot et al., 2011).

Recovery constitutes a systematically structured and objective-driven physiological and psychological restoration protocol, intended to re-establish an individual’s optimal neuromuscular and cognitive functioning. This rehabilitative endeavor is initiated with the aim of reinstating the pre-competition homeostasis of a sportsperson's performance state. An ample and strategically administered recovery regimen is critically significant for reinstating the disrupted biomechanical

and metabolic equilibrium in an athlete's physical output. In the context of 3v3 basketball, where playes are frequently required to engage in multiple high-intensity matches within a single competitive day, the implementation of adequate recovery protocols becomes indispensable. Empirical investigations into training modalities and recuperative interventions, alongside longitudinal evidence accrued over recent years, have conclusively established that elite performance enhancement is not solely contingent upon progressive training stimuli. Instead, it necessitates a meticulously optimized equilibrium between physical load application and recovery, thereby mitigating the risk of psychological burnout and physiological dysregulation (Dupuy et al., 2018).

## STATEMENT OF PROBLEM

The aim of this study is to examine the impact of selected recovery strategies on physiological variables and physical ability after 3 versus 3 basketball match.

## RESEARCH QUESTIONS

- Whether active recovery has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match?
- Whether massage has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match?
- Whether foam rolling has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match?
- Whether the combination of active recovery and massage has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match?
- Whether the combination of active recovery and foam rolling has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match?
- Which recovery strategy is best for the restoration of physiological variables and physical ability after a 3 versus 3 basketball match?

## OBJECTIVES OF STUDY

The objectives of the study are:

- To investigate whether active recovery has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball matches.
- To investigate whether massage has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball matches.
- To investigate whether foam rolling has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball matches.
- To investigate whether the combination of active recovery and massage has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball matches.
- To investigate whether the combination of active recovery and foam rolling has a significant effect on the restoration of physiological variables and physical ability after a 3 versus 3 basketball matches.
- To find out the best recovery strategy for the restoration of physiological variables and physical ability after a 3 versus 3 basketball matches.

## DELIMITATIONS

1. The study will be delimited to 21 male basketball players.
2. The study will be delimited to the subjects who had at least participated in INBL or RED BULL HALF COURT Tournament
3. The study will further be delimited to players of Haridwar District of Uttarakhand state.
4. All participants will be between 18 and 25 years of age.
5. The study will be delimited to following recovery strategies–
    - Active recovery
    - Massage
    - Foam rolling
    - Active recovery + massage
    - Active recovery + foam rolling
6. The study will be further delimited to the following physiological variables –

- Blood Lactate
- Heart rate
- Body temperature
- Blood pressure (systolic)
- Blood pressure (diastolic)

7. The study will further be restricted to 3 physical ability variable-
    - Sprinting ability
    - Explosive strength
    - Agility

## HYPOTHESES

1) It is hypothesized that there would be a significant effect of active recovery on the restoration of physiological variables and physical ability after a 3 versus 3 basketball matches.

2) It is hypothesized that there would be a significant effect of massage on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match.

3) It is hypothesized that there would be a significant effect of foam rolling on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match.

4) It is hypothesized that there would be a significant effect of the combination of active recovery and massage on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match.

5) It is hypothesized that there would be a significant effect of the combination of active recovery and foam rolling on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match.

6) It is hypothesized that there would be a significant difference in the effects of different recovery strategies on the restoration of physiological variables and physical ability after a 3 versus 3 basketball match.

## DEFINITION AND EXPLANATION OF THE TERMS

**BLOOD LACTATE:** A fatigue-inducing byproduct of the lactic acid energy system, resulting from the incomplete breakdown of glucose and accumulating in the blood and muscles (Plowman et al., 2011).

**HEART RATE:** The speed at which heart beats.

**BODY TEMPERATURE:** It is a measure of your body's ability to make and get rid of heat.

**BLOOD PRESSURE (SYSTOLIC):** Indicates the pressure exerted on the artery walls when the heart contracts and pumps blood.

**BLOOD PRESSURE (DIASTOLIC):** Represents the pressure in the arteries when the heart is at rest between beats.

**SPRINTING ABILITY:** To move rapidly or at top speed for a brief period, as in running or swimming.

**AGILITY:** The ability to move your body and change direction quickly and easily.

**EXPLOSIVE STRENGTH:** It refers to the capability to overcome resistance with high speed.

**ACTIVE RECOVERY:** An active recovery workout involves performing low-intensity exercises following a strenuous workout.

**FOAM ROLLING:** a self-myofascial release (SMR) technique used to alleviate muscle tightness, reduce soreness, and decrease inflammation.

**MASSAGE:** The rubbing and kneading of muscles and joints of the body with the hands, especially to relieve tension or pain.

## SIGNIFICANCE OF STUDY

The study may contribute in the below mentioned ways:

- The outcomes of this study may provide important insights for the coaches and 3 versus 3 basketball players in identifying the most appropriate method of recovery after an exhaustive 3 versus 3 basketball match.
- The outcomes of this study may provide important insights for determining the appropriate time of recovery following particular recovery method.
- The outcomes of this study may provide important insights for 3 versus 3 basketball players who don't have access to an assistant for the purpose of training and recovery, as all the recovery strategies can be self-managed.

- The outcomes of this study may provide important insights for 3 versus 3 basketball players who need to participate in 3 versus 3 basketball match which require subsequent performance that is of very exhaustive in nature.
- The outcomes of this study may provide important insights in accelerating the recovery process of 3 versus 3 basketball players after an exhaustive basketball match.

# CHAPTER II

# REVIEW OF RELATED LITERATURE

The researcher has gone through literature available which were relevant to do present study. A brief review of the same which the investigator came across is enumerated below:

**S. Gupta (1996**) conducted a comparative physiological investigation to evaluate the efficacy of three distinct recovery modalities on post-exercise blood lactate clearance. The study examined passive recovery (sitting rest), active recovery at 30% of maximal oxygen uptake ($VO_2max$), and short-duration manual body massage. A cohort of ten trained male athletes was recruited for the experimental protocol. The exercise regimen involved intermittent cycling on a calibrated bicycle ergometer at an intensity equivalent to 150% of $VO_2max$. Each exercise bout lasted one minute and was interspersed with 15-second rest intervals, continuing until the subjects reached volitional exhaustion. Blood lactate concentrations were systematically measured at post-exercise recovery time points of 0, 3, 5, 10, 20, 30, and 40 minutes. Simultaneously, key metabolic and cardiovascular parameters, including oxygen uptake ($VO_2$), carbon dioxide production ($VCO_2$), and heart rate, were recorded at 30-second intervals for a duration of 30 minutes. The highest mean blood lactate accumulation was seen consistently at the 3-minute mark across all recovery modalities. Statistical analysis revealed a significantly reduced lactate half-life during active recovery (15.7 ± 2.5 minutes), whereas short-term massage (21.8 ± 3.5 minutes) and passive sitting recovery (21.5 ± 2.8 minutes) demonstrated comparable and notably prolonged lactate clearance durations. Moreover, the data represented that oxygen consumption was elevated during massage recovery relative to passive sitting, yet this increase in metabolic activity did not translate into enhanced lactate removal. The comparative analysis of lactate kinetics between massage and passive recovery yielded no statistically significant distinctions. Therefore, the findings conclusively suggest that short-duration massage lacks efficacy as a recovery modality for accelerating lactate clearance. In contrast, active recovery emerges as the most efficient strategy for promoting post-exercise metabolic restoration and optimizing lactate elimination.

**Hemmings** (**2001**) executed a comprehensive investigation with the primary aim of elucidating the multifaceted applications of massage therapy within the athletic domain, where it is prevalently

employed for purposes such as injury mitigation, alleviation of fatigue, induction of relaxation, and the potential augmentation of athletic performance. This scholarly article critically synthesizes the extant empirical literature concerning both the utilization and physiological, psychological, and performance-related outcomes of massage therapy in sports contexts. Methodology: A systematic literature review was undertaken utilizing databases including Medline, Psychlit, and Sport Discus, supplemented by relevant unpublished data and the investigator's personal archival records. Findings: Previous investigations evaluating parameters such as peripheral blood flow, post-exercise blood lactate clearance, and delayed onset muscle soreness (DOMS) have yielded inconclusive and often contradictory outcomes. Notably, evidence indicates that active recovery modalities are generally more efficacious than massage in promoting lactate clearance. Investigations into psychological outcomes remain limited in scope; however, emerging studies suggest that massage may positively influence subjective perceptions of recovery and well-being. Empirical evaluations examining the direct impact of massage on athletic performance are sparse and offer minimal empirical support for its efficacy in enhancing performance metrics. Conclusions: The current body of massage-related research suffers from heterogeneity in methodological approaches, inconsistencies in measurement instrumentation, and limited replicability, which collectively hinder the formulation of definitive conclusions. The widespread application of massage in sport appears to be underpinned more by anecdotal evidence and experiential reports than by robust scientific validation. The present review underscores the imperative for more rigorously designed experimental investigations to delineate the exact physiological and psychological mechanisms by which massage may exert its effects on athletes. Nevertheless, incorporating standardized scientific methodologies into massage research presents considerable experimental and practical challenges for scholars in this field.

**Javier Monedero** (**2000**) systematically conducted a controlled investigation aimed at evaluating the comparative efficacy of various post-exercise recovery modalities following maximal exertion. A cohort of eighteen well-trained male cyclists was recruited to initially perform a graded exercise test designed to ascertain their individual maximal oxygen uptake ($VO_2max$). Four distinct recovery strategies were subsequently examined: (i) passive rest, (ii) active recovery at an intensity corresponding to 50% of $VO_2max$, (iii) sports massage, and (iv) a composite intervention integrating both active and massage components. All experimental sessions were temporally spaced by intervals of 48 to 72 hours to mitigate residual fatigue effects. During each trial,

participants completed two simulated 5-kilometer maximal cycling time trials (denoted T1 and T2), separated by a 20-minute recovery period utilizing one of the specified interventions. The primary variables assessed included performance times for T1 and T2; blood lactate concentration (BLa) measured at the end of each trial and at 3-minute intervals during recovery; and heart rate (HR) monitored continuously throughout the recovery phase and during T2. Statistical analyses revealed that the combined recovery strategy significantly outperformed passive recovery ($P < 0.01$) and showed superior effectiveness compared to either active recovery or massage alone ($P < 0.05$) in preserving performance output during the second time trial (T2). Furthermore, active recovery exhibited the most pronounced efficacy in facilitating BLa clearance at the 9th and 12th minute marks. At minute 3, combined recovery achieved significantly greater BLa reduction than passive recovery, and at minute 15, it was notably more efficient than all other modalities evaluated. In summary, the combined recovery modality emerged as the most efficacious approach for sustaining high-intensity performance during repeated maximal efforts, while active recovery was identified as the most potent strategy for accelerating metabolic by-product clearance, particularly blood lactate, during the post-exercise recovery window.

**E Victoria Wiltshire (2009)** conducted a controlled experimental investigation aimed at evaluating the mechanistic hypothesis that sports massage facilitates post-exercise skeletal muscle recovery primarily through augmentation of regional muscle perfusion, thereby enhancing the clearance of exercise-induced metabolic byproducts such as lactic acid. This study specifically tested whether increased local blood flow contributes to the accelerated removal of intramuscular lactate. Twelve healthy participants underwent a standardized 2-minute protocol of strenuous isometric handgrip (IHG) exercise performed at 40% of their maximal voluntary contraction (MVC), intended to elevate lactate concentrations within the forearm musculature. Subsequent assessments included measurement of forearm blood flow (FBF) using Doppler and echo ultrasonography of the brachial artery, as well as quantification of deep venous blood lactate ([Lac]) and proton ion concentration ($[H^+]$) at one-minute intervals for ten minutes post-IHG under three distinct recovery modalities: passive rest, active recovery via rhythmic contraction at 10% MVC, and manual sports massage involving effleurage and petrissage techniques. Baseline arterialized [Lac] and $[H^+]$ values were obtained from a superficial, thermally dilated dorsal hand vein. Data, expressed as mean ± standard error (SE), indicated no statistically significant difference in the venoarterial lactate concentration gradient ([Lac]v-a) at 30 seconds post-IHG among

conditions (passive = 6.1 ± 0.6 mmol/L, active = 5.7 ± 0.6 mmol/L, massage = 5.5 ± 0.6 mmol/L; not significant). However, FBF was significantly higher in the passive condition (766 ± 101 mL/min) relative to both active recovery (614 ± 62 mL/min; P = 0.003) and massage (540 ± 60 mL/min; P < 0.0001). The area under the curve (AUC) for total FBF over 10 minutes post-IHG was significantly higher in passive rest compared to massage (4203 ± 531 vs. 3178 ± 304 mL; P = 0.024), though not significantly different from active recovery (3584 ± 284 mL; P = 0.217). Lactate efflux, calculated as the product of FBF and [Lac]v-a, mirrored these trends (passive = 20.5 ± 2.8 mmol vs. massage = 14.7 ± 1.6 mmol; P = 0.03; vs. active = 15.4 ± 1.9 mmol; P = 0.064). Additionally, $H^+$ efflux was significantly elevated in the passive condition relative to massage at both 30 seconds (2.2 ± 0.4$e^{-5}$ vs. 1.3 ± 0.2$e^{-5}$ mmol; P < 0.001) and 1.5 minutes (1.0 ± 0.2$e^{-5}$ vs. 0.6 ± 0.09$e^{-5}$ mmol; P = 0.003) following IHG. The findings suggest that post-exercise massage, while commonly utilized for recovery, paradoxically attenuates the removal of lactate and hydrogen ions from exercised muscle, most likely due to its mechanical restriction of blood flow and subsequent inhibition of metabolite clearance.

**Hartono (2019)** undertook a controlled experimental investigation to evaluate the comparative efficacy of foam rolling (self-myofascial release), manual massage, and cold water immersion (ice bath) interventions on post-exercise blood lactate clearance and the attenuation of delayed onset muscle soreness (DOMS). A total of thirty third-semester undergraduate students enrolled in the Faculty of Sport Sciences were selected through randomized sampling and equally distributed into three intervention groups: roller massage, traditional massage, and ice bath treatment. All participants performed the Running-based Anaerobic Sprint Test (RAST) following a standardized 10-minute warm-up protocol. Blood lactate concentration was initially quantified eight minutes post-RAST using a portable lactate analyzer. Subsequently, the roller massage group received self-myofascial release via foam rollers for a duration of 5 minutes, the manual massage group underwent traditional massage therapy for 5 minutes, while the ice bath group was immersed in water maintained at 10°C for 5 minutes. Post-treatment BLA levels were then re-assessed. Normality of data for the roller massage group yielded a p-value of .022, while Levene's test for homogeneity of variances showed p = .133, necessitating the application of the non-parametric Kruskal-Wallis statistical test. Contrary to the outcomes reported in existing literature, the ice bath condition demonstrated superior efficacy in promoting lactate clearance (mean = 17.40), surpassing both the massage (mean = 16.65) and roller massage (mean = 12.45) conditions.

Similarly, ice bath therapy was most effective in mitigating DOMS (mean = 12.25), followed by massage (mean = 13.95) and roller massage (mean = 20.30), although differences were not statistically significant ($p = .399$). The enhanced lactate clearance in the ice bath group is hypothesized to be facilitated by vasoconstriction-induced hemodynamic adjustments, with individual physiological phenotypes also potentially influencing outcomes. Moreover, the thermoregulatory cooling induced by ice immersion is posited to exert potent analgesic effects.

**Devlin (2014)** conducted a scientific inquiry with the primary objective of determining the optimal intensity of active recovery required for effective post-exercise blood lactate clearance, particularly following maximal, all-out exertional efforts known to elicit substantial lactate accumulation. Recognizing that fatigue onset during high-intensity physical exertion is frequently associated with rapid blood lactate accumulation, the study addressed a critical gap in identifying precise recovery intensities. A standardized maximal treadmill protocol was developed to consistently induce voluntary exhaustion and achieve post-exercise blood lactate concentrations exceeding 10 mmol/L. Participants then performed repeated all-out sprinting efforts elevating lactate to an average of 11.5 ± 0.2 mmol/L, followed by recovery exercises at intensities ranging from 0% (passive recovery) to 100% of their individually determined lactate threshold. The study's findings, derived from repeated measurements, indicated a statistically significant enhancement in lactate clearance during active recovery compared to passive modalities ($p < 0.01$). Furthermore, recovery intensities within the range of 60–100% of the lactate threshold demonstrated greater efficiency in lactate reduction than lower intensities ($p < 0.05$). Notably, the most effective lactate clearance was observed at an active recovery intensity of 80% of the lactate threshold, which was characterized by the shortest time constant and highest clearance rate ($p < 0.05$). A graded response was evident across recovery intensities: 100% = 60% > 40% > passive recovery ($p < 0.05$). These findings underscore the intensity-dependent nature of post-exercise lactate metabolism, emphasizing the superiority of submaximal active recovery—specifically at 80% of lactate threshold—for expediting metabolic recovery following exhaustive exercise.

Micklewright (2003) systematically investigated the combined effects of massage therapy and active recovery on the kinetics of blood lactate removal following supramaximal anaerobic exertion, using the 30-second Wingate Anaerobic Test (WAnT) as a benchmark. Twenty-five healthy adult subjects underwent an estimation of maximal oxygen uptake ($VO_2max$) via the

YMCA incremental cycling test. After a standardized 5-minute resting phase, participants performed the WAnT and were then randomly assigned to one of five post-exercise recovery conditions: (i) passive sitting rest (n=5), (ii) lower limb massage (n=5), (iii) low-intensity active cycling at 37.5% $VO_2$max (n=5), (iv) alternating passive rest and active recovery (n=5), and (v) combined massage with active recovery (n=5). Blood lactate concentrations were measured using enzymatic-amperometric analysis from fingertip blood samples. Statistical analyses revealed that both the active recovery group and the combined massage-active recovery group exhibited significantly greater relative reductions in blood lactate concentrations compared to the passive rest group ($p < 0.05$). Among these, the combined intervention showed promise due to its superior energy efficiency and increased subjective comfort levels. The findings suggest that the integration of passive massage with low-intensity aerobic recovery may optimize post-exertional lactate clearance while minimizing physiological discomfort, thereby offering a potentially advantageous strategy for enhancing post-performance recovery dynamics.

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# CHAPTER- III

# METHODOLOGY

This chapter outlines the methodological framework encompassing the selection of participants, identification of relevant variables, determination of criterion measures, test administration procedures, data acquisition protocols, and statistical techniques applied to the data analysis.

## SELECTION OF SUBJECTS

21 Basketball players, (Age ranging between 18 to 25 years) will be purposely selected from haridwar district of uttarakhand state who has at least participated in INBL or RED BULL HALF COURT Tournament.

## SELECTION OF VARIABLES

Upon critical evaluation of existing scholarly literature, the following recovery strategies—considered as independent variables—will be identified and selected, each representing a distinct methodological approach within the broader spectrum of recovery modalities. i.e.

1. Active Recovery
2. Massage
3. Foam Rolling
4. Active Recovery + Massage
5. Active Recovery + Foam Rolling

Physiological variable:

1. Blood lactate
2. Heart rate
3. Body temperature
4. Blood pressure (systolic)
5. Blood pressure (diastolic)

Following physical ability variables are selected:

1. Sprinting Ability

2. Explosive Strength
3. Agility

## TEST AND CRITERION MEASEURES

The tests and standard measures used for assessing recovery-related physiological and physical ability indicators are shown below..

| S. No. | Variable | Test and Instrument | Criterion Measure |
|---|---|---|---|
| 1 | Blood Lactate | Blood Test (Blood Lactate Analyser) | Mmol/L |
| 2 | Heart rate | Heart Rate Monitor | Beats/min |
| 3 | Body Temperature | Thermometer | Degree celcius |
| 4 | Blood Pressure (systolic) | Digital sphygmomanometer | Mmhg |
| 5 | Blood Pressure (diastolic) | Digital sphygmomanometer | Mmhg |
| 6 | Sprinting Ability | 15m Sprint Test | Sec |
| 7 | Explosive Strength | Standing Broad Jump | Meter |
| 8 | Agility | T- Test | Sec |

## EXPERIMENTAL DESIGN

The same cohort of participants will be subjected to multiple treatment conditions across successive trials, with data systematically collected on predefined variables at multiple temporal points—specifically, pre-competition, post-competition, and following recovery phases. Accordingly, a within-subjects experimental framework incorporating repeated measures design will be implemented for this investigation.

**Within-Within Group Design**

| **Recovery Strategies** | **Time Points** | | |
|---|---|---|---|
| TREATMENTS | PRE-MATCH | AFTER-MATCH | AFTER (10,15) MINUTES OF MATCH |
| R1 | S1-S21 | S1-S21 | S1-S21 |
| R2 | S1-S21 | S1-S21 | S1-S21 |
| R3 | S1-S21 | S1-S21 | S1-S21 |
| R4 | S1-S21 | S1-S21 | S1-S21 |
| R5 | S1-S21 | S1-S21 | S1-S21 |

***S = Subjects, R = Recovery Strategies**

Data on selected physiological and physical performance variables will be collected at regular time points after applying different types of recovery treatments.

- ✓ Heart rate, blood lactate, body temperature, SBP, DBP (before match, immediately after match, at 10 minutes after match and 15 minutes after match).
- ✓ Sprinting ability, explosive strength, agility (before match, immediately after match, after 15 minutes of recovery strategy).

## TREATMENT PROCEDURE

The methodology employed for administering the various recovery strategies is outlined in the following section -

**Active Recovery-**

Following the completion of the 3 versus 3 basketball match and recording the values of physiological variables and physical ability variable, the players will be asked to perform simple jog at 50- 60% intensity as a means of active recovery for a total of 15 mins.

**Massage-**

Following the completion of 3 versus 3 match and recording the values of physiological variables and physical ability variables subjects will be given the massage therapy (combination of effleurage, petrissage, vibration and tapotment) for a duration of 15 mins.

**Foam Rolling-**

After recording the post 3 versus 3 Basketball match values of physiological variables and physical ability variables, subjects will be asked to perform foam rolling on various body parts (all the subjects will be taught how to perform foam rolling on various body parts) for an aggregate duration of 15 minutes.

**Active Recovery + Massage-**

Once the post-match values of various physiological and physical ability variables are recorded, all the subjects will be asked to perform normal jog at 50-60% intensity for 8 minutes followed by a quick massage (combination of effleurage, petrissage, vibration and tapotment) for a duration of 7 minutes, total duration of this combination of recovery strategies will be 15 mins.

**Active Recovery + Foam Rolling-**

After recording the post-match values of various physiological and physical ability variables, subjects will be asked to perform normal jog at 50-60% intensity for eight mins as a form of active recovery, followed by the application of foam rolling for a duration of seven minutes, making a total duration of fifteen mins for this combination of recovery strategies.

## ADMINISTRATION OF TEST

**Blood Lactate-**

Blood lactate concentration will be assessed using a blood lactate analyzer. A test strip will be inserted into the device, and a small blood sample will be obtained via fingertip puncture using a

lancing device. A drop of blood will be applied to the strip, and the analyzer will display the lactate concentration in mmol/L, which will be recorded as the individual's score.

**Heart Rate-**

A heart rate monitor will be utilized to assess heart rate in terms of beats per minute (bpm).

**Body Temperature-**

Digital thermometer will be used to measure the body temperature in degree Celsius.

**Blood Pressure (Systolic)-**

Systolic blood pressure will be measured using an automated blood pressure monitor. The cuff will be positioned around the proximal arm, with its lower margin placed approximately one inch above the antecubital fossa. Upon activation of the device, the systolic blood pressure will be automatically recorded, and the displayed value will be documented as the subject's measurement score.

**Blood Pressure (Diastolic)-**

Diastolic blood pressure will be assessed using a digital sphygmomanometer. The cuff will be positioned around the proximal arm, ensuring that its lower edge is placed approximately one inch above the antecubital fossa. Upon activation of the device, diastolic pressure will be measured automatically. The displayed reading will be recorded as the participant's blood pressure score.

**Sprinting Ability-**

The assessment consists of performing a single maximal-effort sprint over a 15-meter distance, with time recorded in seconds. Subjects will be asked to sprint for a distance of 15 meter on the signal go and time taken to complete it will be recorded as individual score.

**Explosive Strength-**

Explosive strength will be assessed using the Standing Broad Jump Test. The athlete will position themselves behind a designated line on the ground with feet shoulder-width apart. A two-footed take-off and landing technique will be employed, utilizing arm swing and knee flexion to generate forward momentum. The athlete will attempt to jump the maximum possible distance. The distance from the take-off line to the nearest point of contact on landing will be measured and recorded in meters as the individual's performance score.

**Agility-**

Agility will be assessed using the T-Test. The participant will commence at Cone A. Upon the timer's signal, the participant sprints forward to Cone B, located 10 meters away, and touches the base with the right hand. Subsequently, the participant performs a lateral shuffle to the left toward Cone C, situated 5 meters from Cone B, and touches its base with the left hand. The individual then shuffles laterally to the right toward Cone D, positioned 10 meters from Cone C, and touches its base with the right hand. Next, the participant shuffles back to Cone B, touches it with the left hand, and finally runs backward to Cone A. Timing will cease once the participant crosses Cone A. The total time taken to complete the drill, measured in seconds, will be noted as the individual's agility score.

## COLLECTION OF DATA

For the purpose of this study, participants will be gathered on the basketball court and briefed on the study's objectives, procedures, and significance. To ensure familiarity with the testing environment, all participants will be oriented to the testing conditions two days prior to the initiation of the protocol, thereby confirming that they are thoroughly familiar with all testing procedures.

After doing the proper warmup according to the instruction of the researcher, the baseline data for all the physiological variables (blood lactate, heart rate, body temperature systolic and diastolic blood pressure) will be taken at the 0- minute time point (pre-data), than the subjects will play a

standard 3 versus 3 basketball match whose intensity will be monitored throughout the match using polar chest strap and again the data will be taken after the 3 versus 3 basketball match (post-data 1) and while giving the recovery modality at 10 minutes (post-data 2) and at 15 minutes (post-data 3) time point.

After doing the proper warmup according to the instruction given by the researcher, the initial measurements of all physical performance variables (sprinting ability, explosive strength, agility) will be taken at 0-minute time point (pre-data) along with the physiological variables, after which subjects will play standard 3 versus 3 basketball match whose intensity will be monitored throughout the match using Polar chest strap and then again the data will be taken after the 3 versus 3 basketball match (post-data 1) and again after performing the recovery strategy (postdata 2).

A three-day interval will be maintained between each recovery intervention and the subsequent 3v3 basketball match, as well as before the administration of the next recovery strategy. All participants will undergo each of the selected recovery protocols, and their effects will be assessed through designated physiological and physical performance variables.

## STATISTICAL TECHNIQUE

Descriptive statistics will be employed to summarize the key characteristics of the dataset, while a two-way repeated measures ANOVA will be utilized to evaluate the effects of the selected recovery strategies on physiological variables and physical performance outcomes.
A significance level of 0.05 will be adopted for all statistical analyses.

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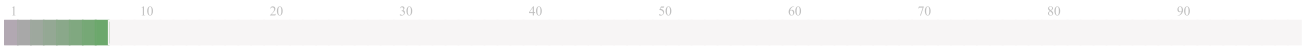


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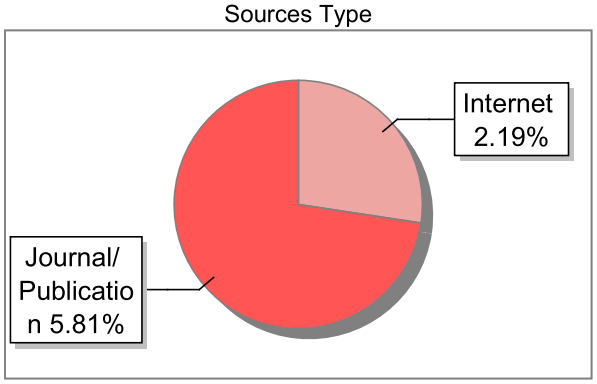


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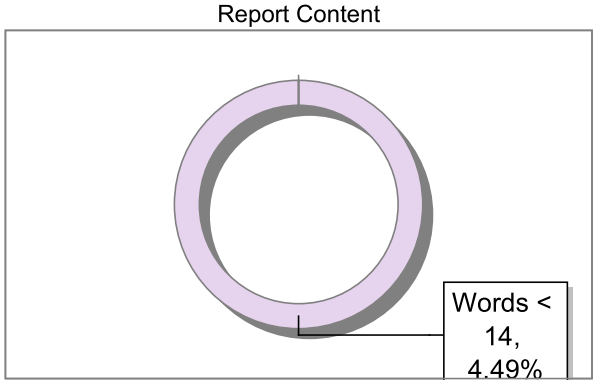


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